– Dogfish, Cod, Pigeon & Rabbit. –

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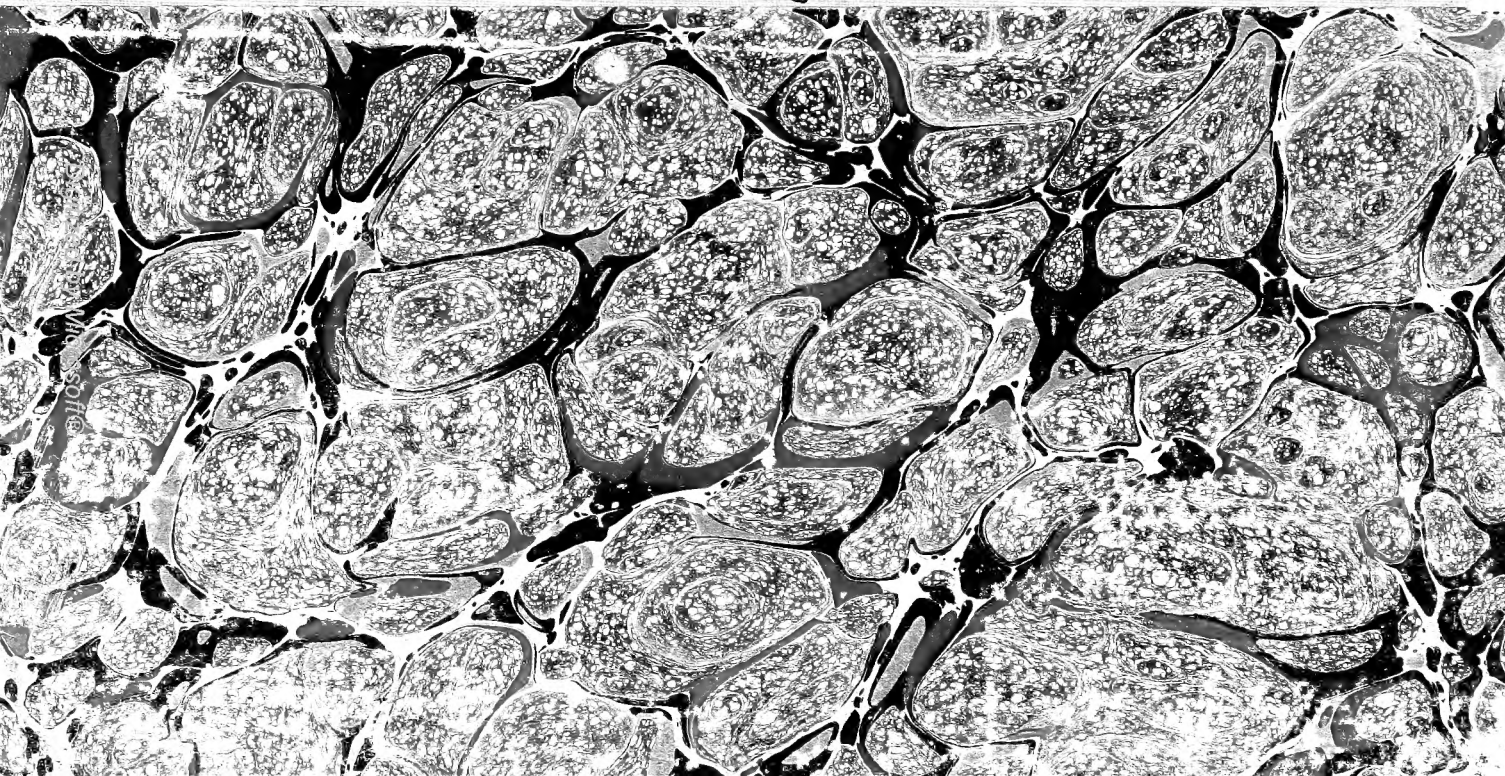

MORPHOLOGY OF THE VERTEBRATA.

DOG-FISH, COD, PIGEON,

AND

RABBIT:

WITH

DEVELOPMENT OF THE DOG-FISH.

PART I.

GEORGE DRYDEN.
EDINBURGH: 54A LOTHIAN STREET.
1883.

MORPHOLOGY OF THE VERTEBRATA.

DOG-FISH, COD, PIGEON,

AND

RABBIT.

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THOS. GRAY AND CO., PRINTERS, GEORGE STREET, EDINBURGH.

PREFACE.

THE following pages are intended as a guide to those about to commence the practical study of Zoology.

In selecting the Dog-Fish, Cod, Pigeon, and Rabbit, I have done so, as they are easily procurable, and serve as good types of their respective classes.

Each animal has, for simplicity, been described in detail:—First, commencing with the external characters, then going on to the alimentary tract and viscera, at the same time taking up the generative organs. After that a description is given of the respiratory and circulatory apparatus, following which is a short account of the nervous system; and, finally, the skeleton is treated of.

Each animal is described from many careful dissections, and illustrations are given of those points which might appear difficult. We should advise the student to provide himself with two specimens of each animal, one for the examination of the soft parts, and the other for the preparation of skeleton. For the latter object it is best, after cutting off muscle, etc., to macerate in water in some hot place for three weeks, not disturbing the jar or pot until the bones are taken out to be cleaned.

In conclusion, I have to state that certain facts in the course

of the descriptions are on the authority of the writings of Gegenbauer, Parker, and Owen, notably the latter.

I must apologise to the reader for an accidental error in Plate I., containing skull of Dog-Fish: there are no teeth in the dry skull, as is represented.

At the end of the book is inserted notes on the Development of the Dog-Fish, derived from the late Professor Balfour's work on the "Embryology of the Elasmobranchs."

D. KNIGHT.

CONTENTS.

MORPHOLOGY OF THE VERTEBRATA.

DOG-FISH.

Class—Pisces. *Order*—Elasmobranchii. *Sub-order*—Selachoidei. *Type*—Scylium (Dog-Fish).

Note elongated pointed snout, and that mouth is on under surface of the head, some distance from anterior extremity of body. It is of great capacity, being the common entry to both the digestive and respiratory organs; and as the transmission of the food to the stomach, and of respiratory currents to the gills, is performed by similar acts of deglutition, the bony arches which encircle the mouth are large, and there is a complicated mechanism for directing the nutriment and the oxygenating water each to their respective destination. In front of the mouth are the two nasal apertures, and on either side of it the external auditory openings. Following at some distance from the mouth are five vertical clefts on each side—these are the external openings of the branchial sacs, which look backwards. Immediately behind the last branchial cleft are the pectoral fins. In front of the junction of middle third with posterior third of body are the ventral fins, with the anus between their apposed bases. The attenuated posterior end of body is continued into the heterocercal tail. On upper surface of head behind each eye is an opening—the spiracle—which leads into the cavity of the mouth, and is the remains of the first branchial cleft of the embryo. On dorsal median line are two fins—the dorsal fins—one being anterior and the other posterior. In some species of dog-fish a sharp thick spine is inserted in front of the dorsal fins, which is known as a *dermal defence*, this being of the same nature as the fossils ichthyodorulites. The entire body is covered over by sharp, closely set spines, arranged in regular oblique rows—the whole constituting the shagreen. Each spine or denticle agrees with a tooth in structure, being developed in a papilla of the true skin, or corium. A wavy line, the lateral line, runs on each side of the body from behind the head to the tail. As the description of this is more easily seen in the cod, its structure will be described a few pages on.

ALIMENTARY TRACT.

Teeth are developed upon the mucous membrane covering the palato-quadrate cartilage and the mandible: these are never implanted in sockets.

The basis of the tongue is composed of the glossohyal bone, and its surface is smooth and devoid of papillæ. There are no salivary glands or tonsils, but mucous follicles pour their secretion into the mouth. The entry to the gullet is simply constricted by a sphincter muscle.

The œsophagus is a short and wide canal, with a thick muscular coat; its mucous membrane is longitudinally folded to allow of increased capacity for unmasticated and often very large food. It is not uncommon to find a large-sized fish in the stomach in specimens after death. Numerous recurved processes project from the inner surface of the œsophagus.

The stomach is simple, and is a large extensive sac, with a great disproportion in size of cardiac and pylorice orifices. The inner surface is rugose at the cardiac end: a circular pyloric valve is well developed. The intestinal canal is shorter than the body itself. The true homologue of the small intestine is extremely narrow and short. It loops upwards from lower end of stomach, and receives the ducts of the liver and pancreas. Beyond the openings of these ducts it suddenly expands into the large intestine, which is straight and very short in proportion to the length of the body, and is continued to the anus, which opens into the fore part of the cloaca.

To recompense for the great shortness of the intestinal canal, the absortive area of the mucous membrane of the large intestine is increased by being raised into spiral transverse folds, forming the so-called "spiral valve," which runs throughout the entire length of the large intestine in a cork-screw-like manner. This spiral valve is both the homologue and analogue of the valvulæ conniventes of some mammals, man included.

The stomach and intestines are invested by the peritoneum, and are connected with the dorsal wall of the abdominal cavity by the mesogastric and mesenteric folds of the peritoneum.

The cavity of the peritoneum is in communication in front with that of the pericardium, to be presently alluded to, and behind communicates with the exterior by two pores.

THE LIVER

Is of large proportional size, and is remarkable for the great quantity of fine oil in its substance. It is attached at the fore part of the abdomen to the aponeurotic wall, partitioning off the

pericardium, and extends backwards farther on the left than the right side. It consists of two lobes, which occupy a considerable portion of the abdominal cavity, and embrace the other viscera below. The gall bladder, of small size, is situated towards the fore part of the liver, and is attached to its right lobe.

PANCREAS

Is a spongy conglomerate gland, placed by the commencement of the small intestine. Its duct terminates in a papilla, a short distance from the pyloric valve.

KIDNEYS

Are two elongated convoluted bodies of a whitish colour, which are situated on either side of the spine, extending as far forward as the pectoral girdle.

The ureter, after quitting the hinder part of each kidney, dilates into a kind of receptacle, behind each oviduct or vas deferens, and communicating with its fellow near the cloaca, terminates, by a single urethral canal, in the cloaca behind the anus. The ureters should be inflated through this opening with a blow-pipe.

GENERATIVE ORGANS.

Male—The testes are very small, except in the breeding season, and are situated far forward in the abdominal cavity. They have a capsule—the tunica albuginea—which sends septa into the substance of the gland, which consists of the tubuli testes, separated by a small amount of connective tissue. Numerous vasa efferentia convey the semen to the beginning of the vas deferens, which, by its many convolutions, forms a large epididymus. These gradually decrease as the duct approaches the cloaca, when it becomes straight, and expands into an elongated receptacle, the surface of the mucous membrane of which is increased by many transverse folds. Posterior to the termination of the rectum, the vasa deferentia suddenly decrease, and nearing one another, communicate with the ureters.

Female—Ovary is single, and placed symmetrically in the fore part of the abdominal cavity. It is round in shape, dense in structure, and relatively small. The fallopian tube or oviduct opens promixally into the cavity of peritoneum, between the liver and peritoneal septum; while at its distal end it is dilated into a uterine cavity, which opens into the cloaca, being distinct from the ureters.

HEART

Is a muscular sac invested in pericardium, situated just in front of pectoral arch, below the hind part of the gills. It consists of an auricle, which receives venous blood from a sinus venosus, and a ventricle, which is continued into an aortic bulb, which, in virtue of its striped muscular fibres, is rhythmically contractile. The interior of the bulb is provided with four transverse rows of valves. Sinus venosus—a development of the termination of the venous system, is situated just behind auricle, and is only partly covered by the pericardium. The wall of the auricle is thin, its only function being to impel blood into the ventricle. The ventricular wall having a more powerful function to perform, viz., to impel the blood throughout the entire body, is in consequence proportionally thick. It is internally provided with stout muscular bands—the musculi papillares—which project into its cavity. There are two membraneous valves at the auriculo-ventricular opening, which prevent, after the contraction of the auricle, the reflux of blood into that chamber.

The pericardium is perforated, communicating with the cavity of the peritoneum by the pericardio-peritoneal canal, which bifurcates, after leaving the pericardium, into two canals, which, after diverging from one another, open into the peritoneum opposite the termination of œsophagus. The course of the circulation is as follows:—The blood is collected by the great veins into the sinus venosus, which pours its contents into the auricle, by the contraction of which the ventricle becomes filled. The ventricle, contracting in its turn, propels the blood through the aortic bulb to the gills, where it is ærated. From the gills it is carried by efferent branchial vessels, which by their confluence form the dorsal aorta—from where the blood is distributed to all parts of the body. From this it is observed that the ærated blood which has passed through the gills is not returned to the heart, but is driven from the branchiæ into the aorta, from where it is conveyed all over the body. The propulsive force necessary for this is derived from the heart itself, the valves in the aortic bulb giving full effect to the contraction of the muscular wall of the bulb.

RESPIRATORY ORGANS

Are in the form of five fixed flattened pouches. The branchial chamber is divided by four partitions into five chambers, and the branchial laminæ are attached by the whole of one margin to each septa. In this manner five pouches are formed, each of which opens inwardly into the pharynx by a separate slit. The branchial clefts are not covered by any opercular membrane as in the cod.

NERVOUS SYSTEM.

Fishes inhabit water in every part of the globe, and occupy it at different depths, and are required to subsist on various sorts of nourishment; and as they must therefore have different capacities, they must have corresponding variations in the structure of their bodies. The appetite for food appears to be their predominant desire, and providing for its gratification to form their chief occupation: and as this is very voracious, they must be constituted not only with a peculiar digestive apparatus but with subtlety for taking their prey, and strength for pursuing it, as well as for defending themselves against the attacks of their enemies. To the varying functions of the different organs the nervous system is appropriately adapted. When the sense of smelling is most conducive to their convenience, as in the dog-fish, there is a capacious nose, large olfactory nerves, and large anterior lobes of the brain; and when seeing is more advantageous, as in the cod, the anterior lobes are smaller, and the olfactory nerves decrease in the same ratio; the eyes are consequently large, and the optic nerves and parts of the brain from which they originate are proportionate with them. Besides the different form and size of the several portions of the brain generally existing, it is furnished with additional lobes when extraordinary powers are necessary.

Brain consists of a large cerebellum covering the fourth ventricle, the sides of which are folded, and known as the *restiform bodies.* In front of the cerebellum is the mesencephalon, and in front of this the thalamencephalon. The cerebral hemispheres are united in the middle line; the olfactory lobes are continued from the anterior lateral portion of the cerebrum, and they dilate into large ganglionic masses before they enter the olfactory sacs.

The optic nerve is seen passing to the eye. The third nerve is seen passing to all the muscles of the eye, except the superior oblique and external rectus. The fourth is seen passing to the superior oblique muscle, and the sixth to the external rectus. The fifth is seen giving off three principal trunks beside the auditory. The first passes in two divisions through the orbit; these become united at the anterior part of this cavity, and the nerve is then continued forwards, giving branches to the cellular structure in its course towards the end of the snout. The second trunk passes on the fore part of the muscles of the jaw, gives a large branch, which distributes filaments to these muscles and the upper and lower lips; it gives a large branch to the cellular structure on the ventral surface of the snout, this also gives

branches to the upper lip; it gives a large branch to the cellular structure at the side of the head. The third trunk passes behind the muscles of the jaw, gives branches to these, and is distributed on the skin about the mouth and gills; one of its branches forms a ganglion, which gives off filaments to terminate about the under lip. The auditory portion of the fifth passes to the ear, and gives branches to the sacs containing the cretaceous matter and the globular enlargements of the semicircular canals, whilst a nerve similar to the glosso-pharyngeal communicates with it on the large sac, and gives filaments to the termination of a semicircular canal, and then passes outwards to give filaments on the surface of the first and the corresponding one of the second division of the gills, and terminates on the membrane of the mouth. The vagus is seen passing to the gills, giving filaments to the muscular appendages of these, and then sending a large branch to distribute filaments to every part of the opposite surface of each division, except the first; it sends a branch anteriorly to the stomach, which communicates with the sympathetic; it sends a large branch posteriorly to pass underneath the muscles of the back, and give filaments to these in its course; this branch lies upon and crosses the spinal nerves; near the tail it emerges from underneath the muscles, and passes just under the skin to the extremity of this part.

The optic nerves unite into a chiasma, but do not decussate.

ORGANS OF SENSE.

EAR.

External aperture of, situated at margin of gape on under surface of skull.

The labyrinth—the essential portion of the organ of hearing—is entirely enclosed within cartilage. The semicircular canals are arranged in the ordinary manner, being three in number.

NASAL SACS.

Cavity of nasal chamber is double, each part opening by a separate aperture on the under surface of skull at sides of mouth. The interior of the olfactory chamber is lined by mucous membrane, arranged in such a manner as to form numerous folds, by

which its surface is increased in area, all of which are richly supplied by branches of the olfactory nerves. Posteriorly the nasal sacs are closed, there being no communication with the pharynx, as there is in Mixine and Lepidosiren. Two processes project from the margin of each nasal opening towards one another, and divide the original simple aperture into an efferent and afferent orifice. The olfactory sac is connected with the mouth by the nasal groove, which extends from the sac to the angle of the gape. This represents the nasopalatine canal of man.

EYE.

Notice that anterior segment of the bulb is very much flattened. The sclerotic coat is cartilaginous in texture. The ciliary processes of choroid are rudimentary.

A highly vascular plexus—the *choroid gland*—lies on outer side of choroid. The upper and lower lids are represented by two small moveable pieces.

THE SPINAL COLUMN

Consists of the persistent notochord, with rudiments of the superior and inferior cartilaginous arches which grow around it, and so form cartilaginous circular centra. The entire vertebral column is divisible into not more than two distinct regions—an abdominal and caudal region. The abdominal vertebræ possess a superior or neural arch, through which the spinal cord passes, a superior spinous process—the neural spine, and a transverse process on either side, to which the ribs are attached. There are no marked transverse processes in the caudal vertebræ, but below the body of the vertebræ are given off inferior or hæmal arches, which carry inferior spinous processes—the hæmal spines. The extreme end of the spine is bent up so as to form an obtuse angle with the trunk part of the spine, and the median fin-rays which lie below it are much longer than those which lie above it, causing the upper division of the caudal fin-rays to be much smaller than the lower. This kind of tail is known as heterocercal.

The first vertebra articulates with the skull by a single median facet.

The ribs are rudimentary, and are buried in the muscles. They do not enclose a thoracic cavity as in higher vertebrates, and there is no sternum.

SKULL

Is composed of cartilage without any trace of sutures, and devoid of membrane bone; it articulates with vertebral column by a median facet. The maxillæ and premaxillæ are absent. Teeth are developed in the mucous membrane, which covers palato-quadrate and mandible. It is on account of this that these cartilages are so well developed. The anterior end of right and left palato quadrate are connected by ligaments.

The sympletic is represented by a process of the hyomandibular.

Cartilaginous filaments pass outwards from the branchial and hyoidean arches, and support the walls of the branchial sacs.

Mandibular arch consists of two pieces, the upper one, the palato quadrate, which is articulated to the base of the skull.

The most anterior part of skull—ethmoidial region—on the inferior surface of which is a nasal pit on each side. The cephalic cartilage is prolonged forwards between the nasal pits into a rostrum. The succeeding portion of the skull forms the orbits, which is bridged over in front and behind by cartilage. Following behind the orbital portion is the labyrinthic portion, which encloses the labyrinth or essential organs of hearing. This is continuous behind with the occipital segment. In the middle line, between the labyrinthic segment and occipital, is a deep depression, at bottom of which are two foramina.

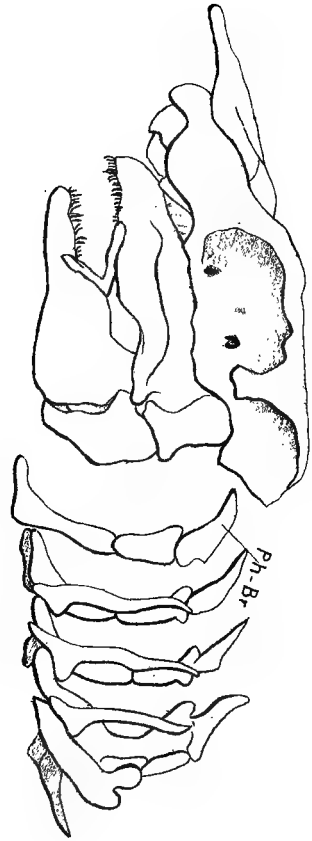
BRANCHIAL SKELETON

Supports that part of the alimentary canal which subserves respiration. It is made up of complicated cartilaginous rods, which superiorly are connected with the spinal column by the pharyngo-branchial rods, and ventrally are united with one another by single pieces—the copulæ.

The hyoid arch has the same arrangement as the branchial arches.

SHOULDER GIRDLE

Is seen in its simplest form. It is composed of a piece of cartilage, which forms an arch on either side, being united to its fellow along the ventral median line, and placed just behind the last branchial cleft. The muscles which move the pectoral fins are attached to it. It is not connected with skull.



PECTORAL FIN

Is composed of a stem which is made up of jointed pieces of cartilage, which articulate with the shoulder girdle by the intermediation of three basal cartilages. The central stem is beset on each side with lateral rays, which are jointed in a similar manner as the stem.

PELVIC GIRDLE

Is formed of two coalesced cartilages. The venteral fins have the same characters as that of the thoracic, with the exception that the rays are arranged in a less complicated manner.

bladder are derived from the vagus and sympathetic, and its function is a mechanical one, regulating the specific gravity of the cod, and aiding it to maintain a particular level in the water.

THE KIDNEYS

Form two elongated reddish-brown organs, which are situated beneath the spinal column above the air-bladder, and extend the whole length of the abdominal cavity, from the head in front to the tail behind. They are divided, for descriptive purposes, into three parts—the fore, hind, and middle kidney. They are broadest and thickest anteriorly. The renal tissue is soft and spongy, and is supplied by numerous small arteries from the abdominal aorta. They receive a great part of their blood from the caudal vein, which ramifies in them.

The ureter passes directly downward, and dilates inferiorly into a bladder, which lies behind the rectum, and consists of two portions, marked by a constriction. The bladder should be carefully blown out through the urethra. The urethra continued from the bladder is a short tube, which opens behind the genital apparatus.

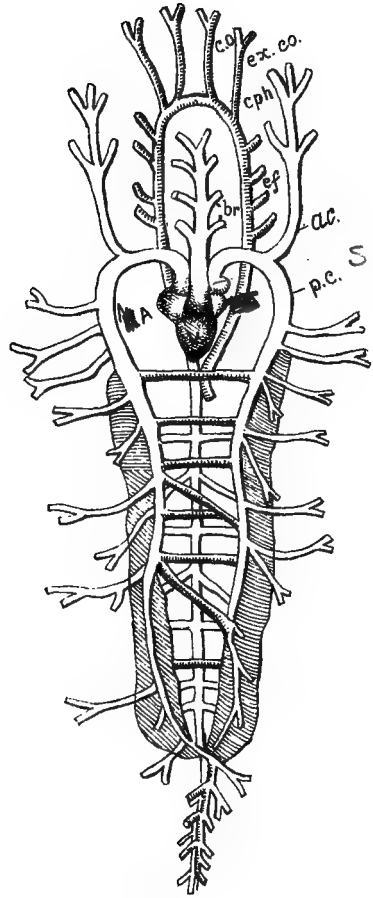
GENERATIVE ORGANS.

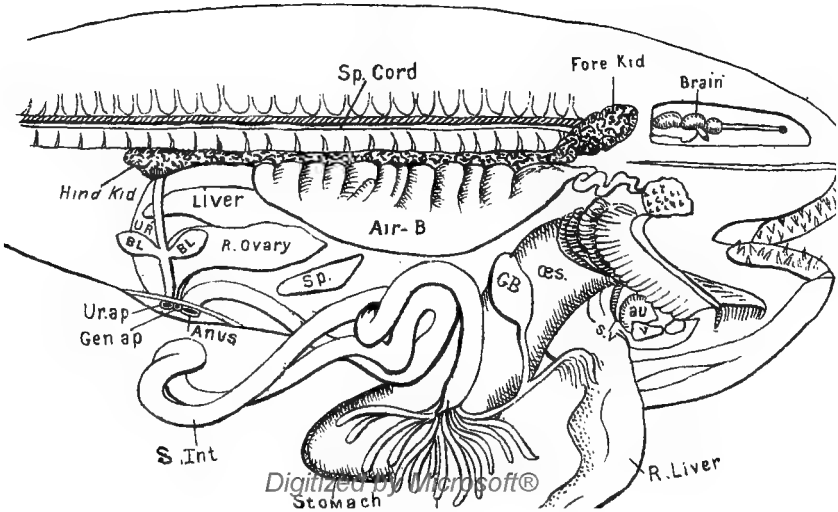
Male—The testes are remarkable for their enormous increase at the breeding season. When fully developed, they are commonly known as the "soft roe." The greater part of their substance is composed of the tubuli seminiferi, which open at one end into the wide commencement of the vas deferens, and terminate at the other by blind extremities.

Female—The ovaries, popularly known as the "hard roe," form two lengthened sacs, with a thin fibrous investment and a peritoneal covering, being closed in front, but produced behind into a short and wide oviduct, which coalesces with its fellow of the opposite side into a single tube—the common terminal portion being much dilated, and terminating behind the anus in front of the urethra. The stroma, or that part of the ovary which is the seat of development of the ova, is extended by being plaited into numerous transverse folds.

CIRCULATORY SYSTEM.

The *heart* has the typical piscine structure. It consists of a sinus venosus, pouring its blood into the single auricle, and a single ventricle receiving blood from the auricle. The ventricle is continued into the aortic bulb, from which it is separated by a





single row of valves. The aortic bulb differs from that of the dog-fish in not being rythmically contractile. The cardiac aorta —the continuation upwards of the aortic bulb—divides into four trunks the *afferent* branchial vessels, which carry the venous blood to the gills; they course round the outer side of the branchial arches, and supply each filament. The now arterialised blood is collected into the *efferent* branchial vessels—one for each gill. Each of these open into a trunk on either side—in fact, form it—the right and left aortic arch. These two pass backwards, and meet in the middle line beneath the vertebral column, and form the dorsal aorta.

The most anterior efferent branchial vessel gives off a large carotid branch, which runs forward under the base of the skull, and this is joined with its fellow by a transverse branch, so that an entire arterial circle—the circulus cephalicus—is formed beneath the base of the skull. The most anterior efferent branchial vessel also gives off the hyoidean artery, which courses along the hyoidean arch, and usually terminates by a branch in the cephalic circle, and by another enters a rete mirabilia, which is situated in the inner side of the hyomandibular bone, and sometimes simulates a gill in appearance, and hence known as the pseudobranchia. The branches given off from the rete mirabilia join again into the opthalmic artery, which, piercing the sclerotic, breaks up into a second rete mirabilia—the so-called choroid gland, before its final distribution.

The efferent veins of the kidneys form on either side the posterior venæ cavæ, which open separately into the sinus venosus. Just before their entrance into the sinus venosus, the posterior venæ cavæ receive the anterior venæ cavæ, which return the blood from the anterior part of the body.

RESPIRATORY ORGANS.

The branchiæ are situated in two special chambers. placed on each side of the neck. They are carried upon the outer convex sides of the branchial arches, which are a series of bony arches, five in number, connected below with the hyoid arch, and above united with the base of the skull. The concave borders of the branchial arches are beset with a series of processes, which project inward toward the mouth, the function of which is to prevent the passage of any particles to the branchiæ which might injure their delicate structure. The branchiæ themselves have the form of a double series of vascular plates or lamellæ. These lamellæ are flat and pointed in shape, and are covered with a very vascular mucous membrane, in which the capillaries of the branchial vessels ramify. The number of plates on one process has

PECTORAL ARCH

Consists of the clavicles, long knife-like bones, pointed below, where they meet each other in the middle line, and connected together by ligament. Attached to their dorsal end is another smaller bone, the supraclavicle, which articulates with another bone forked in front—the post-temporal: one fork of which is connected with the epiotic, and the other to the pterotic.

Attached to the back of the clavicle are two small bones, above the scapula, and below coracoid; articulating with these are five basal cartilages, to which the fins are attached. The clavicle gives attachment to a styliform bone, the post clavicular, which runs back among the lateral muscles.

SKULL.

As the arrangement of the various bones of the skull can be readily seen by a glance at the accompanying plate, we only purpose to draw attention to the most important points concerning them.

The articular cup in the basioccipital for the atlas is a deep conical excavation.

The homologue of the suspensorium of the dog-fish ossifies so as to give rise to two bones: an upper broad hyomandibular, with which the sperculum articulates; and a low style-shaped bone—the sympletic—which is firmly held into a groove on the posterior inner suface of the quadrate.

Meckel's cartilage persists throughout life, but its proximal end is ossified into the os articulare of the lower jaw.

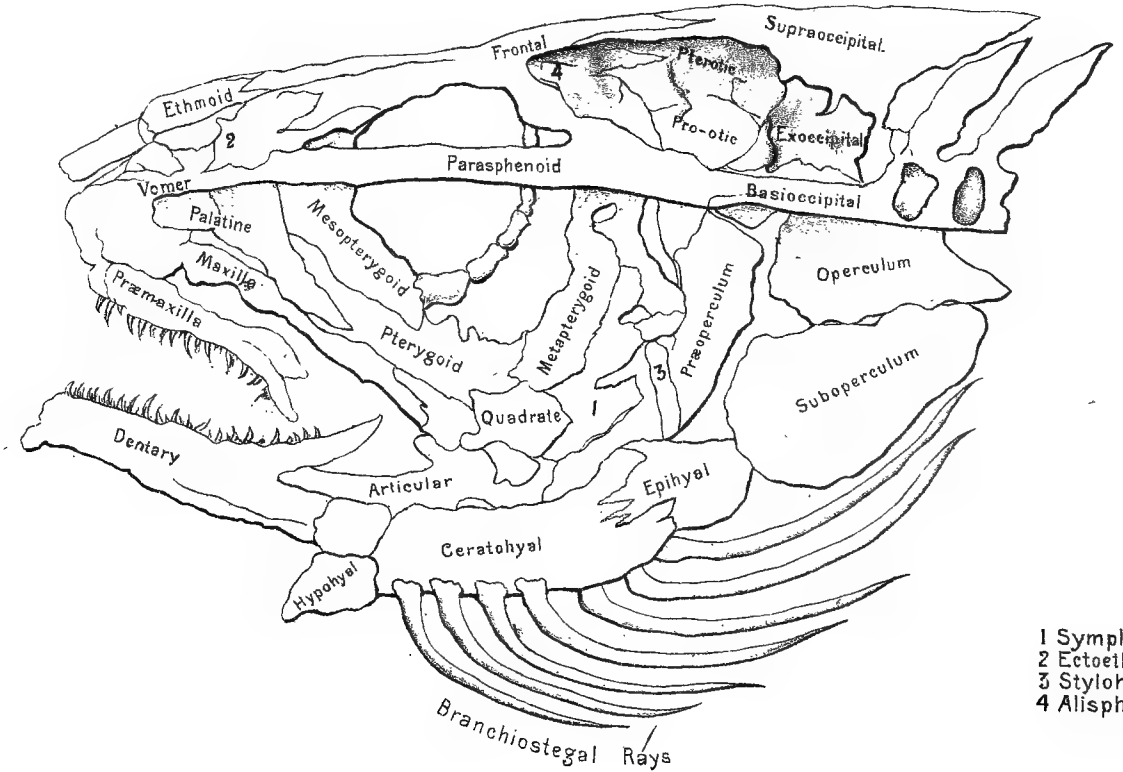
On the under surface of the skull are two membrane bones—the vomer in front, and the large parasphenoid behind, which covers in all the base of the cranium from the basioccipital to the vomer.

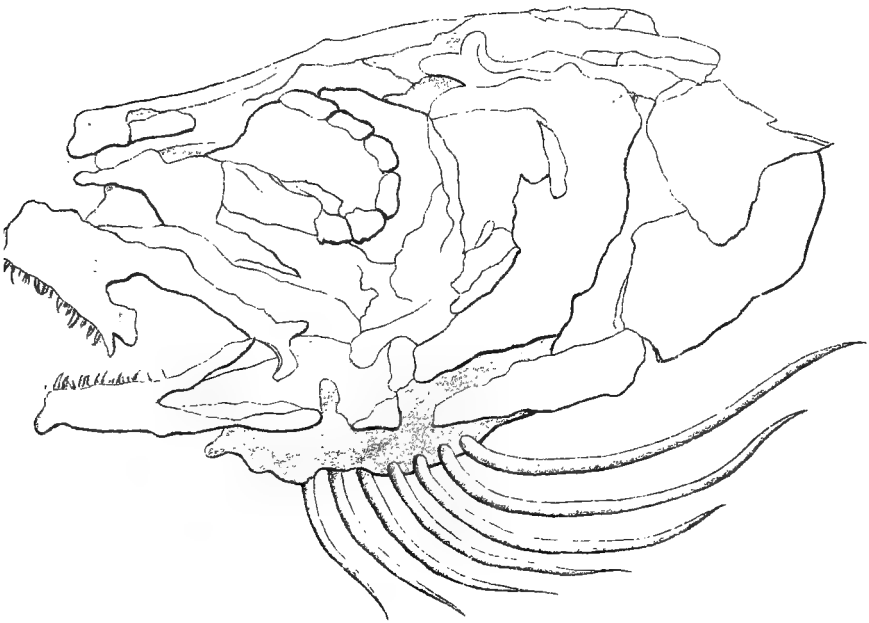
The ethmoidal cartilage remains unossified.

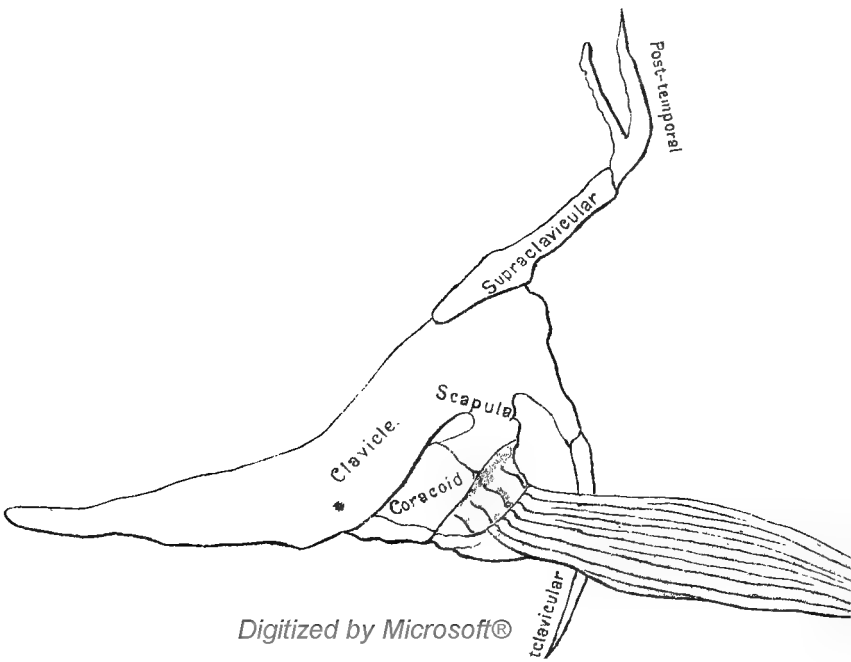
The opisthotic is a distinct bone, and the prootic well developed, being placed in front of the anterior vertical semicircular canal, and behind the exit of the third nerve.

The maxillæ take but little share in the formation of the gape, which is bounded by the backwardly extended premaxillæ above.

The palato-quadrate arch is represented by the palatine in front, and the quadrate behind. In addition to these is an external ectopterygoid, an internal entopterygoid, and a metapterygoid, which envelopes the upper and posterior part of the primitive quadrate cartilage.







PIGEON.

Class—Aves. *Order*—Carinatæ. *Type*—Columbus (Pigeon).

Body covered with feathers, which are a modification of the epidermis. Take one of the larger feathers and examine for the following parts:—

(1) A central axis—the *scapus*—forming the stem of the feather, and divided into a lower hollow part—the *calamus* or quill—where its base is implanted in a small sac of the cutis vera.

(2) A *rachis* or shaft, which is four-sided, and is simply a continuation of the calamus; and

(3) The shaft which carries the lateral processes (barbs) of the feather, collectively forming the *vexillum*.

The calamus at its lower end has an aperture, through which the pulp holding blood-vessels enter the shaft. The barbs are narrow processes, which at their free end taper to a point, and at their bases are attached to the rachis. The margin of the barbs are furnished with smaller processes, which form an open angle with the barb, and hold the same relation to the barb as the barbs do to the rachis. The extremities of the barbules are hooked, so that the opposed margins of the barbs interlock together through the medium of these barbules.

Each feather sac—into which the lower end of the calamus is fitted—is provided with small muscles, which by their contraction can elevate the feathers. In the integument over the coccyx is the *uropygial* or oil gland—this is a modification of a sebaceous gland, and secretes an oily liquid, which the pigeon covers its feathers with in the act of preening.

Note the position of the external nares, which are placed at the sides of the upper mandible. They are wide and freely open, to allow of easy ingress of air during respiration. The nasal passages communicate with the palate and pharynx by two distinct but contiguous apertures: a bristle should be passed through the external nares to verify this. The external meatus of the ear is seen behind and somewhat below the eye; and, by careful inspection, a fold of the integument may be seen projecting from the fore part of the meatus.

Notice the third eyelid or nictitating membrane.

ALIMENTARY TRACT.

The tongue is hard, and, like the mandibles, is ensheathed in horn. It essentially consists of a prolongation of the glossohyal bone, and is chiefly adapted to fulfil the function of a prehensile organ, in association with the beak. Salivary glands are developed on each side of the interior of the mouth, and pour their secretion on the food prior to deglutition. It is destitute of papillæ, except at its base: these papillæ are supplied by filaments of the glossopharnyngeal nerve. No branch of the fifth nerve goes to the tongue.

The œsophagus is long, and as it passes down it inclines towards the right side, being partially covered by the trachea, and connected to the surrounding parts by a loose cellular tissue. It is dilated into a pouch: the crop, which is double, consisting of two lateral oval cavities, lodged between the coalesced clavicles. The change the food undergoes in the crop is well known: if a pigeon be allowed to swallow a great number of peas, they will swell to such an amount as almost to suffocate it. Hunter made many observations on the crop of pigeons, which takes on a secreting function during the breeding season, for the purpose of supplying young pigeons in the unfledged state with a suitable diet for their tender condition. An abundant secretion of a milky fluid is poured out into the crop, and mixed with the macerating grains. This is a near approach to the mammary secretion of the mammalia.

The œsophagus, a short distance below the crop, opens into the proventriculus, which corresponds to the pyloric of the stomach of higher animals—a gastric juice being secreted from glands in its walls. At its lower end the proventriculus embouches into the gizzard, a thick-walled muscular sac, situated below the liver on the left side of the abdomen. Its upper end has two apertures: one of these is of large size, communicating with the proventriculus; the second is close to and on the right side of the preceding, leading to the duodenum. Below these apertures, the cavity of the gizzard extends to form a *cul de sac*. At the middle of the anterior and posterior parts of the *cul de sac* there is a tendinous centre, from which the muscular fibres radiate.

In opening the gizzard, notice that the epithelium is developed into a hard horny coat, adapted for triturating the food.

The pyloric orifice of gizzard is guarded by a valve. The intestines reach from the stomach to the cloaca: in relative length they are short. The canal is divided into small and large intestines, by the insertion of two short cœca, which are opposite one another. In the crown pigeon these cœca are altogether wanting.

The large intestine is very short, about one-tenth part of the length of the body, and is continued straight from the cœca to the cloaca. The rectum terminates by a valvular circular orifice in the cloaca.

THE LIVER

Is a large two-lobed organ, which occupies the front part of the abdominal cavity, monopolising a great portion of its space.

The right lobe covers the beginning of the duodenum, pancreas, and part of the small intestines; the left lobe covers the proventriculus and part of the gizzard; while the apex of the heart is received between the upper end of these two lobes. Of the two hepatic ducts, one, the right and larger, enters the beginning of the duodenum, the other near its termination.

The portal veins are of great size.

SPLEEN

Of small size, of a reddish colour, and of oval form, is placed beneath the liver, on the right side of the proventriculus. A process of the pancreas passes into close contact with it.

PANCREAS

Is of large size, and consists of two distinct portions, but these are so closely applied together that they appear like one continuous gland. It is of an elongated and narrow form, and is situated in the fold of the duodenum, and is more or less bent upon itself. It has three ducts, two of which open into the duodenum separately, close to the larger hepatic duct, while the third duct terminates at a distance from the other two.

THE KIDNEYS

Are two elongated organs, placed on either side of the vertebral column, commencing immediately below the lungs, and extending along the spine as far as the termination of the rectum. They are moulded to the cavities and depressions of the pelvis. The posterior surface exhibits inequalities corresponding to the eminences and depressions of the pelvis. Each is invested by a capsule, and consists of three principal lobes.

URETERS,

The duct of the kidney, is continued along the anterior surface of the kidney, receiving branches of the urinary tubules as it passes along. Below the kidney the ureters pass behind the rectum, becoming blended with its coats: they ultimately terminate upon valvular elevations in the cloaca.

The supra-renal capsules or adrenals are of a bright yellow colour, and are placed on the inner side of the superior extremities of the kidneys. They are in contact with the testes in the male, and the left one adheres to the ovary in the female. They have been found to shew an enlargement corresponding to the increased development of the sexual organs. Their function is unknown.

TESTES,

Two in number, of an oval form, are placed near the upper end of the kidneys, the left being usually larger than the right. They are enclosed within a strong tunica albuginea, and are fastened by a fold of peritoneum to the spine. They acquire an immense size at the breeding season. The vas deferens, the duct of the testes, passes down by the side of the ureters, and opens on a papilla in the cloaca anterior to the opening of the ureter. The base of each papilla is surrounded by a plexus of arteries and veins, and serves as an erectile organ during coitus.

OVARY,

Only one, on the left side. The fallopian is long and tortuous, and the ovum or egg, as it passes along it, receives the albuminous investment—the so-called white of egg, which would serve for the nutrition of the embryo had impregnation taken place. At its lower end the fallopian tube is dilated, and it is in this situation that the egg receives the calcareous shell. Lastly, the fallopian tube opens into the cloaca, where the egg is received.

RESPIRATORY ORGANS.

THE LUNGS

Are spongy in texture, and of a bright crimson colour. They are situated in the thoracico-abdominal cavity, and are firmly attached to the ribs and their interspaces on either side of the vertebral column, each lung being moulded to the superjacent vertebræ and ribs. They communicate with the large air sacs which extend into the abdomen.

THE DIAPHRAGM

Is incomplete, and is attached to the ribs outside the borders of the lungs and from the spinal column, and ends by an aponuerotic expansion upon the ventral surface of the lungs. The lungs are two in number, and extend from the second dorsal vertebra to the kidneys, and laterally to the junction of the sternal with the vertebral ribs. The pleura is reflected only over the sternal surface of the lungs.

Each bronchus, as it enters the lung, immediately loses its cartilaginous rings, and, after traversing the lung, ends at its posterior part by opening into one of the abdominal air sacs. Canals are given off from the inner side of the bronchus, which pass to the under surface of the lung, and there open into other air sacs. Of these there are altogether nine—two abdominal, before mentioned, two anteriorly and two posterior thoracic, one clavicular, and two cervical. All these air sacs, except the anterior and posterior thoracic, communicate with an extensive system of air passages, which ramify through most of the bones of the skeleton with the exception of the bones of the skull, which receive their air from the nasal chambers and tympana.

LARYNX.

In the pigeon, as in all birds, there are distinct thyroid, cricoid, and argtenoid cartilages. The voice is not produced in the larynx, however, but in the lower larynx or syrinx. This is situated at the lower end of the trachea, at its point of division into the two bronchi. The syrinx is a complicated apparatus of cartilages and bones, regulated by appropriate muscles. It is developed at the junction of the trachea and bronchi, and from both—hence it is known as the broncho-tracheal form of syrinx.

CIRCULATORY SYSTEM.

HEART

Is cone-shaped, and consists of two auricles and two ventricles. Its apex is placed between the two lobes of the liver. As the lungs are situated dorsally, the whole anterior surface of the pericardium is brought into view when the sternum is removed.

The pericardium surrounds the heart, and adheres by its external surface to the neighbouring air cells. The heart is of large size, and is continued for some distance between the lobes of the liver.

The right auricle is larger than the left. The inner surface of the auricles is marked by the columnæ carnæ and musculi pectinati.

The right ventricle is a narrow cavity of a triangular shape, placed to the right and anterior side of the left ventricle, but not extending to the apex. The right ventricle is characterised by the smoothness and evenness of its inner surface; the pulmonary artery takes its origin from it, and is provided at its commencement with three semilunar valves. It divides into two branches—one for each lung. The left ventricle is a cone-shaped elongated cavity, the walls of which are about three times as thick as those of the right ventricle, and have strong fleshy columns developed on their inner surface, which extend from base to apex.

The aorta springs from the left ventricle—its orifice being guarded by three semilunar valves.

The openings of the auricles into the ventricles are guarded by the auriculo-ventricular valves, which prevent the regurgitation of the blood backwards from the ventricles into the auricles.

The aorta is peculiar in crossing over the right bronchus. It immediately after its commencement gives origin to the two innominate arteries, which send off the common trunk of the carotid and vertebral arteries.

The basilar artery is formed by the internal carotids, and not by the vertebrals. The arteries of the hind extremities do not arise from a single branch or external iliac, but from two arteries which come off successively from the aorta at a considerable distance from each other, and leave the pelvis by two separate apertures.

The inferior vena cava receives the hepatic veins before it opens into the right auricle. There is no renal portal system.

BRAIN.

The cerebrum does not cover the cerebellum, and its chief mass consists of the corpora striati. The lateral lobes of the cerebellum and pons varolii are rudimentary. There are no convolutions on the cerebral hemispheres, and the corpus callosum is not developed.

The optic thalami are of small size, and are not united by a soft commissure: between them is the cavity of the third ventricle.

SKELETON

Exhibits a far higher type than that of fishes.

As the beak in birds is prehensile, the cervical vertebræ are numerous, and freely moveable. In Columbus they are twelve in number.

Atlas is an oval ring-like bone, and the transverse ligament, which is sometimes ossified, divides its aperture into two —the upper, or posterior one, enclosing the spinal cord— and the lower, or anterior one, the odontoid process of the axis, which in reality represents the body of the atlas, as its development shews.

The anterior articular surfaces of the remaining cervical vertebræ are slightly concave from above downwards, and convex from side to side; while the posterior articular surfaces are saddle-shaped, convex from above downwards, and concave from side to side. So in a horizontal section, the centra would appear opisthocœlous, while in a vertical section— procœlous.

This is a well marked character of all birds. The several arches have prominent pre and post-hysapophyses.

DORSAL VERTEBRÆ

Are seven in number, the posterior five being anchylosed to one another. They may be known by their possessing ribs, and being shorter than most of the cervical, but with broader neural arches, in consequence of the greater development of the tranverse processes.

From some of the centra of these vertebræ inferior processes, hypapophyses, are prolonged downwards, to allow of greater space for the origin of the muscles which depress the neck, viz., lougus colli, and recti antici muscles. The centra have cylindrical articular faces, like those of the neck.

The spinous processes are well developed. It is a character of the dorsal vertebræ that they have a small process on the body of the vertebra for the head of the rib, while from the upper part of the neural arch springs a more lengthened tranverse process for the tubercle of the rib.

LUMBAR VERTEBRÆ.

All are anchylosed, with the sacral to form a bone, which is ordinarily known as the sacrum, to the transverse processes of which the iliac bones are attached.

The first has a broad transverse process, which represents the tubercular transverse process of the last dorsal. In all the succeeding lumbar vertebræ this process is prolonged downwards, and in the last, it springs from the centrum and neural arch of the vertebra and constitutes a broad process, which abuts against the ilium.

SACRAL VERTEBRÆ

Are four in number, and are all anchylosed together. From their several arches are prolonged horozontal tranverse processes, which are flattened from above downwards, and unite with the ilia. The inferior surfaces of their centra are deeply concave, forming deep fossæ for the reception of the middle lobes of the kidneys.

CAUDAL VERTEBRÆ.

The anterior of these have lamellar transverse processes. The three first possess ribs, which are anchylosed at their proximal extremities with both the centra and neural arches of their vertebræ, while at their distal expanded ends they abut against the ilium. The anchylosed caudal vertebræ are distinguished by the name urosacral. The succeeding caudal vertebræ are numerous and free, except the most posterior, which are anchylosed into a ploughshare-like bone—named the pygostyle—which supports the so-called preening gland and the quill feathers of the tail (restrices). It is set on the spine, at a nearly vertical angle with the axis of the body.

The bodies of the cervical and of those dorsal vertebræ which are moveable are connected to one another by means of fibro-cartilaginous rings, which extend from the circumference of the one to that of the other. Each ring is prolonged in between two contiguous centra into a disc—the meniscus—which is free on both its anterior and posterior surfaces. This meniscus is perforated at its centre. In this manner the synovial space between any two centra becomes separated into two narrow compartments, communicating with one another by the perforation in the meniscus. In the caudal region, however, the meniscus is united with the faces of the centra of the vertebræ, and so resembles an intervertebral cartilage—like that of man.

THE RIBS

Are flexible arches of bone, which wall in the thoracic cavity below. They are seven in number on either side—each dorsal vertebræ having a rib attached to it. The third, fourth, fifth, and sixth are connected above with the spine, and below with the sternum, through the intervention of the sternal ribs. The first two are free ribs—that is, they have no connection with the sternum. The ribs are situated one behind the other, in such a way that spaces are formed between them, which are named the intercostal spaces. They increase in size from the first to the sixth.

COMMON CHARACTERS OF THE RIBS.

A middle rib should be taken in order to study the typical character of the ribs. Each rib presents for examination two extremities, a superior or vertebral, and an inferior or sternal, and an intervening portion—the shaft. The superior or vertebral end shews a head, neck, and tuberosity. The head articulates with the process before described on the body of the dorsal vertebræ. The tubercle presents an oval surface, for anticulation with the extremity of the transverse process. The neck is the portion included between the head and the tubercle.

The shaft is thin and flat. About its middle, from the posterior margin, a process is given off, which curves upwards and backwards, and overlaps the succeeding rib: this is the uncinate process.

The first and last have no uncinate process. Each rib articulates inferiorly with a straight rod-like bone—the costal rib —which is to be considered as an ossified costal cartilage. The first two ribs have no sternal ribs, while the last sternal rib does not articulate with the sternum directly, but is blended with the preceding costal rib.

The thoracic cavity is completed below by the large expanded sternum, which developes from five centres of ossification. This bone is placed in the middle line, and extends over the abdominal cavity reaching to the pelvis behind.

The upper surface of the body of sternum is deeply concave and boat-shaped, while at its anterior margin is a convex tranverse grove on either side, for the reception of the sternal articulation of the coracoids: these grooves meet in the middle line. The costal border is thickened, and divided by transverse articula ridges for the sternal ribs into hollows, which shew pneumatic foramina.

On the inferior surface of the sternum is a largely developed descending vertical process—the keel. This affords additional area for the origin of the great pectoral muscles which move the wing.

This osseous creast is convex along its inferior margin, being of greatest vertical diameter in front, gradually lessening to its posterior border. Its most anterior extremity is concave.

Along the lateral margins of the body are two processes on either side, placed behind the articulations for the sternal ribs— these afford attachment for fascia, which strengthens the floor of the abdominal cavity behind.

SCAPULAR ARCH

Consists of the scapula, the clavicle, and the coracoid, on each side. The scapula is a long, thin, recurved sabre-shaped bone, being thickest at the front, where it approaches the shoulder joint, at

which point it forms externally the posterior portion of the glenoid cavity. Internally it is produced to meet the clavicle, while at the remainder of its anterior surface it affords strong attachment to the coracoid. The scapula is placed longitudinally, extending backwards from the shoulder, parallel to the vertebral column, to which, however, it presents a slight convexity. Its posterior third is bent downwards at a slight angle. It extends over four ribs.

CORACOID

Is the strongest of the bones entering into the formation of the scapular arch. Its inferior end is expanded transversely, and is received into the corner groove at the anterior margin of the body of the sternum, before described. Its direction is upward, outward, and forward, to the shoulder joint, where it is firmly articulated with the scapula and clavicle, forming with the former the glenoid cavity for the head of the humerus; at the inner side of the humeral end it affords an articular surface for the clavicle.

THE CLAVICLES

Are very early anchylosed into a V-shaped single bone, known as the furculum (merrythought).

The apex of the V is united with the keel of the sternum by a band of fibrous tissue. The principal use of this furcular arch is to act in opposition to the forces which tend, during the downward stroke of the wing, to press the coracoid inwards, and also by an elastic reaction to restore them to their proper position.

FORE-LIMB OR WING

Consists of a humerus, radius and ulna, two carpel bones, metacarpel and phlanges.

THE HUMERUS

Lies parallel to the axis of the body when the fore-limb is in a state of rest, while the fore-arm is in a condition midway between pronation and sipination. The proximal end of the humerus is transversely expanded, and at its extreme end presents a convex articular surface, which fits into the glenoid cavity of the shoulder joint; on either side of this end is a ridge, which gives insertion to the pectoral muscles. Its distal end exhibits two facets, the outer being for articulation with the ulna, and the inner with the radius.

RADIUS AND ULNA.

The former bone is always the more slender of the two. The upper end of the radius shews a cup-shaped depression, for articulation with the inner articular surface of the lower end of humerus. This end has also a convex border next the ulna, for articulation with that bone. The ulna is slightly curved, and the proximal end is most expanded, having an articular excavation for the outer convex surface in lower end of humerus. The distal end of the ulna is slightly expanded into a trochlear joint, which articulates with the two free carpel bones—one, the scapho-lunar, wedged into the radial part; the other, cuneiform, into the ulnar part, leaving an intermediate space for the os magnum, which is confluent with the middle metacarpel.

The two most external of the normal five metacarpels are not represented, but the remaining three are anchylosed together with the os magnum, into a single bone. This bone appears as if it were composed of two metacarpels, united at their extremities, but free in the middle.

The outer metacarpel, that which corresponds to the radius, is the longer portion, and is, as its development shews, composed of two; it carries the digit which has the greatest number of phlanges. This digit answers to the index finger, and consists of three phlanges; the digit attached to the ulnar metacarpel consists of only a single short phalanx.

OS INNOMINATUM

Is composed of three bones—ilium, ischium, and pubis—all of which are indistinguishably anchylosed. In the young pigeon, these bones were distinct. It is remarkable for the great elongation, both anteriorly and posteriorly, of the iliac bones, which unite with the entire length of the sides of the sacrum. There is an articular surface on the ilium, upon which the great trochanter of the femur plays, called the antitrochanter. The ischium broadens posteriorly, extending back nearly parallel to the hinder part of the ilium, being united with it by ossification behind. The pubis, after entering into the formation of the acetabulum, passes downwards and backwards as a slender curved bone, nearly parallel with the ischium. It is united with its fellow only by fibrous tissue, there being no symphysis pubis.

FEMUR

Is a short bone with a small head, which fits into the acetabular cavity of the innominate bone. The head is sessible on the shaft—that is, it has no neck.

THE TIBIA

Is the chief and longest bone of the hind limb. The shaft is straight and expanded at both extremities, being most so at the proximal end. On the outer side of the upper end is a surface for union by ligament with the head of fibula. At the lower third of the shaft, the styliform end of the fibula is anchylosed to it. To its lower end the oscalcis and calcaneum—the two largest bones of the tarsus—are firmly and indistinguishably united.

THE FIBULA

Is a short styliform bone, about two-thirds the length of the tibia, free at its upper end, but ancylosed to the lower one-third of the tibia. The upper end of the fibula articulates with the outer condyle of the femur: this is an important character in all birds.

TARSUS.

The proximal portion of this, as before mentioned, is anchylosed to the lower end of the tibia (viz., oscalcis and astragalus).

The distal portion, viz., the scaphoid cuboid and three cuneiform bones, are anchylosed to the second, third, and fourth metatarsal bones, to form the most characteristic bone in the leg of the pigeon, viz., the tarso-metatarsal bone. This bone presents a proximal end, with two articular cavities for the lower end of the tibia, and at its distant end is divided into three trochlear condyles for the second, third, and fourth phlanges. There is also at the distal end a rough impression on the inner side for that of the first metatarsal.

THE TARSO-METATARSAL

Is followed by the digits, which consist of three toes directed forwards, and one backwards—the hallux, which consists of two phlanges; the index, or the most internal of the three anterior toes, is composed of three phlanges; the middle, of four; and the outermost, of five.

The fifth toe is not developed, as in all other birds.

The toes are mechanically flexed when the pigeon is roosting by the action of a muscle, which runs from the pelvis, and is attached to the flexor tendons of the toes.

SKULL.

The various bones that compose the skull are fused together in the adult pigeon, the sutures all being obliterated.

At the back and under part is a round foramen—the foramen magnum—which gives passage to the termination of the spinal cord. At its posterior part is a single rounded condyle—the occipital condyle—by which the skull articulates with the atlas of the spinal column.

The nasal apertures are situated far back, near the base of the beak.

THE ORBITAL CAVITIES

Are large, and placed laterally, and encroach upon the anterior wall of the cranium—the septum separating the two being very thin and delicate, and more or less incomplete. The roof of the orbit is formed from before backwards by the frontal, prefrontal, and lachrymal; and the hind wall by the frontal, alisphenoid, and basisphenoid. The brain case is arched and spacious. The beak is chiefly formed of the premaxillæ, which are triradiate bones of large size, and which give off three processes: a frontal process, which ascends to the frontal; one placed along the middle of the palate—the palatine process—to the palatine bones; and an external maxillary process, which composes the greater part of the side of the beak, and unites with the maxilla. The two bones are very early anchylosed, and form a single coalesced bone, which is sometimes known under the name of the intermaxillary.

THE MAXILLA

Is a slender bone, expanded in front into the notch between the palatine and maxillary processes of the premaxilla, being united also to the nasal and vomer. Posteriorly it is bifurcated where it joins the jugal and palatine.

THE PALATINES

Are long slender bones. Anteriorly they pass under the maxillo palatines, and unite with the premaxillæ—they join behind with the pterygoids. Posteriorly the palatines converge toward the rostrum of the basisphenoid, and are united to it by an articular surface, which permits of a sliding movement of the palatines upon the basisphenoidal rostrum. The pterygoids are straight and slender bones. Their anterior or inner ends converge and meet, while their posterior or outer end presents

fossa, for the articular head on the inner side of the distal end of the quadrate bone. The quadrate is the moveable bone by which the lower jaw articulates with the skull. It is articulated in front with the prootic, alisphenoid, and squamosal; while its distal end articulates with the mandible below—the pterygoid on the inner, and the quadrato-jugal on the outer side.

THE QUADRATO-JUGAL

Is a long and very slender bone, situated below the orbit. Posteriorly it presents an articular head, which is received into a fossa on the outer distal end of the quadrate. In front, it is connected with the maxilla.

From this arrangement it follows that when the mandible is depressed, the quadrate is thrown forward, which movement causes the quadrato-jugal and maxilla to move upward and forward; at the same time the pterygoids and palatines glide forward upon the basisphenoidal rostrum—thus it comes about that the beak is elevated when the pigeon opens its mouth.

THE SQUAMOSAL

Is chiefly applied to the side of the skull, and is anchylosed to the other bones.

THE VOMERS

Are early united into a single bone. It is narrow and elongated, and in front it is pointed. Behind it is connected with the palatines. The posterior nares lie between the palatines and the vomer.

The eustachian tubes run through the basisphenoid, and open by a common aperture upon the middle of the under surface of the skull.

THE BEAK

Consists of an upper mandible, supported by the maxillæ and premaxillæ, and of a lower mandible formed by the lower jaw. These bones are provided with a sheath of horny fibrous tissue in place of teeth—this sheath being moulded to the shape of the osseous mandibles.

THE SENSE OF TASTE

Is imperfectly developed in the pigeon, as in other birds which, having no masticatory organs, swallow their food almost as soon as it is seized.

RABBIT.

Class—Mammalia. *Order*—Rodentia. *Sub-order*—Duplicidentata. *Type*—Lepus (Rabbit).

Body covered with hair, which extends over the under surface of the feet and into the interior of the mouth, so that on the inside of each cheek is a band of hair.

There are five digits to the manus (fore foot), the pollex being small. The hind limb is longer than the fore limb, and has four digits. The large eyes are furnished with a third or nictitating eyelid, which contains a triangular cartilage. The large lachrymal gland lies above and on the outer side of the eyeball. The upper lip is cleft in the middle.

The recurved penis of the male has a scrotal sac on each side. The female has five pairs of teats, placed along the side of the abdomen. Both the male and female have perineal glands, which are sac-like involutions of the integument—the duct of a gland situated at the sides of the penis or clitoris opens into them.

The stomach is simple, and the pancreas is diffused and very large, being situated in a fold of the duodenum: its ducts are two,—one, the larger, opens into the intestine about eighteen inches from the pylorus, far removed from the biliary duct; while the smaller one opens just by the bile duct.

The cæcum is very large, and has attached to it a glandular vermiform appendix at its free end.

The kidney has a single papilla, which projects into the pelvis of the kidney.

The female has two uteri, which are entirely separate, and both open into a common vagina.

The vagina and urinary bladder communicate with the vestibule which opens to the exterior. The clitoris is formed by the united corpora cavernosa, and is the representative of the penis in the female, and, like the penis, is pierced by the urethra.

In the male rabbit the inguinal canal remains permanently open, and the vas deferens opens into the large uterus masculinus, which is situated behind the neck of the bladder, and which communicates with the posterior and inferior wall of the urethra, just behind the openings of the prostatic ducts. There is a bone in the penis, and vesiculæ seminales and prostatic glands are present. The testes remain in the abdomen, and come down into the groin in the breeding season.

The thoracic cavity is separated from the abdominal by a well-developed diaphragm (compare this with pigeon.) The heart is four-chambered, as in all other mammals, and there are two anterior venæ cavæ. The external jugular vein is very much larger than the internal.

Of the muscles, attention may be drawn to the plantaris. This muscle is peculiar in being very large, and terminating in a tendon almost as large as the tendo achillis, which runs over the end of the os-calcis, being separated from the tendo achillis by a synovial sac. In the sole of the foot it divides into four tendons, which are perforated for the long flexor tendons of the digits. We mention this muscle because it differs from that of all other mammals in the aspect we have alluded to.

BRAIN.

The cerebral hemispheres do not cover the cerebellum, and the fissure of Sylvius is rudimentary. The olfactory nerves are immense. The corpus callosum is relatively small, and its anterior end is but slightly bent downwards. There is only one corpus mammillare, and in the corpora guadrigemina the nates are larger than the testes. The corpora trapezoidea are well developed.

SKELETON.

Seven cervical and nineteen dorso lumber vertebræ, twelve of these being dorsal.

The transverse processes of the atlas are much expanded, and the axis has a prominent long antero-posterior neural spine; while all the remaining cervical vertebræ have short spines.

The spinous and transverse processes of the dorsal vertebræ are well developed, the latter and the most anterior transverse processes being especially prominent. At the eighth a process, or metapophysis, springing from the side of the body of the vertebræ between the spinous and transverse processes, becomes developed; and in the following vertebræ this increases in size, till in the lumbar region it becomes the length of the spinous process. It is short in the last lumber and obsolete in the sacrum, but is discernable through the anterior caudal vertebræ.

The transverse processes of the lumber vertebræ are exceedingly long, and project downwards and forwards. The transverse process of the first lumber is bifurcated at its extremity. On the ventral sides of the centra of the three most anterior lumbar vertebræ strong median processes are developed, which look downwards and forwards—to these are attached the crura of the diaphragm.

There are four sacral vertebræ, only the first uniting with the ilia.

The tubercles of the second, third, fourth, fifth, sixth, seventh, and eighth ribs are produced into spinous processes, which afford attachment to the tendons of the longissimus dorsi muscle.

The sternum consists of five segments or sternubræ, with a long xiphisternum. The long narrow manubrium is keeled inferiorly.

FORE LIMB.

The acromium of the long narrow scapula sends a process backwards over the infra-spinous fossa, which gives attachment to a portion of the trapezius muscle. The clavicle is slender, buried in the pectoral muscles, and is incomplete at both ends. In the humerus there is supra-condyloid foramen. The radius and ulna are entire and in close contact, and by reason of their hinge-joint with the humerus, the movements of the fore-arm are restricted to that of pronation. There is a ninth bone in the carpus—the os-intermedium. There are five digits, the innermost being very short. They are all ungulate, and provided with claws.

HIND LIMB.

The ilia are long and subprismatic where they articulate with the first sacral—the joint being limited to this vertebra. They extend in advance of this on each side the last lumber, expanding into a crest, which is rough and slightly turned outwards. The pubic bones are long and slender, and meet in the middle line in a long symphysis pubis, which is prolonged into a ridge inferiorly. The femur has a small third trochanter near the base of the great one. The tiba and fibula are anchylosed, and the patella is ossified. There are only two cuneiform bones in the tarsus, the internal one being absent. The navicular has a large process. There is no inner digit, and the inner side of the base of the second metatarsal is extended backwards to articulate with the navicular: this may represent an internal cuneiform.

SKULL.

Dental Formula $\left\{ \text{i } \frac{2—2}{1—1} \quad \text{c } \frac{0—0}{0—0} \quad \text{P. M. } \frac{3—3}{2—2} \quad \text{M } \frac{3—3}{3—3} \right. = 28$

There are no canines. The lower and anterior upper incisors are very long. They are coated with enamel only in front, and they grow continuously from persistent pulps. By attrition they acquire a chisel-shaped edge.

The second pair of incisors in the upper jaw are very small, and are placed behind the first pair. The incisors above and below are separated from the first premolars by a long diastema.

The molars and premolars all grow from persistent pulps, and do not form fangs. Their crowns are transversely ridged. In the young rabbit there are in the upper jaw three incisors and three milk molars on each side. The lower jaw has only two milk molars on either side.

THE PREMAXILLÆ

Are extremely large, and bear the upper incisors. The orbits are not separated by bone from the temporal fossæ. The optic nerves have a common outlet, the optic foramina being confluent, and in this manner the orbits communicate with one another behind. Each orbit presents a wide opening at its front part, which leads into the lateral nasal cavity.

THE ZYGOMATIC ARCH

Developes a small prominence, both from its hind and fore extremities.

THE NASAL BONES

Are remarkable both in their length and breadth. They extend further back than the long, slender nasal processes of the premaxillæ. The tympanic is expanded below to form a bulla.

THE PALATE,

On account of the large size of the anterior palatine canals, is reduced to a narrow bridge of bone, extending across in a line with the premolar teeth.

Post-orbital processes project outwards and backwards from the frontals. The glenoid cavity is elongated from before backwards. The narrow olfactory fossa is continuous behind with the cerebral fossa, which is separated from the cerebellar fossa by an upright tentorial ridge.

In the young rabbit an interparietal bone can be distinguished.

The lower jaw or mandible consists of two separated halves or rami, united in front by a short symphysis. The angle of each ramus forms a broad compressed plate, with the lower border rounded and thickened, so as to project beyond the posterior border of the ascending plate. The ascending portion of the ramus is long, and the condyles are elongated from before backwards, so as to correspond with that of the direction of the glenoid cavity. The coronoid process is well developed.

HYOID BONE.

In this there are nodules, which represent the ceratohyals, the epihyals, and thyrohyals.

DEVELOPMENT OF THE DOG-FISH.

THE OVUM

Is a minute oval body produced in the ovary—it consists of the following parts:—

(1.) A yolk mass.

(2.) A small cell lying on the surface.

This cell is bounded by a dark outline, the vitelline membrane and embedded in it is the germinal vesicle, inside of which again is the germinal spot. The germinal vesicle and spot represent respectively the nucleus and nucleolus.

The germinal vesicle and spot disappear before the ovum leaves the ovary, this being independent of fertilization. Impregnation consists in the entrance into the cell of a spermatozoon. The spermatozoa are the male elements produced from the testes. Each spermatozoon consists of a pointed head with a long tail, and is actively motile, which property is due to the lashings of the tail. After fertilization, the egg on its way down the oviduct receives a new investment of an albuminous material. After impregnation, a furrow appears on the surface of the cell, which, gradually deepening, at length cuts into two: while the same process begins almost immediately in each half, and cuts it also into two. The same process is repeated in each of the quarters, and so on, until at last, by continued cleavings, the whole yolk is converted into a mulbery-like mass, the whole still enclosed in the vitelline membrane. From this it is seen that only a portion of the ovary undergoes segmentation, and is therefore called meroblastic (*i.e.*, part only undergoing division).

The ova of all fishes, birds, and reptiles are meroblastic. On the other hand, in the mammalia and amphibia the entire ovum undergoes segmentation, and is hence termed holoblastic (*i.e.*, whole dividing). The ovum of Amphioxus is likewise holoblastic. When the peripheral cells, which are first formed, are fully developed, they arrange themselves into a kind of membrane at the surface of the yelk, at the same time assume a polyhedral

shape from mutual pressure, so as to resemble pavement epithelium. The deeper cells of the interior pass gradually to the surface and accumulate there, thus increasing the thickness of the membrane already formed by the more superficial layer of cells, while the central part of the yelk remains filled only with a clear fluid. By this means the yelk is shortly converted into a kind of secondary vesicle, the walls of which are composed externally of the original vitelline membrane, and within by the newly formed cellular layer,—the blastodermic or germinal membrane, as it is called. The blastoderm now splits into two layers, called respectively *epiblast* and *hypoblast*. A number of cells now appear apparently from out of the substance of the yelk lying beneath the hypoblast, and migrate in between the epiblast and hypoblast, and so form a third layer or *mesoblast* between the other two.

A groove then appears on the outer or upper surface of the blastoderm, and named the *medullary groove.*

The sides of this groove, which are called medullary folds, rise upwards chiefly from a thickening of the mesoblast, and tend to approach one another. This they ultimately do, first anteriorly, and sometimes afterwards posteriorly. The groove is thus converted into a canal—the spinal canal. A fold has meanwhile appeared anteriorly in direction at right angles to the medullary folds. This fold marks the position of the future head, and is hence called the head fold. It assisted in closing in medullary groove in front, while somewhat later a similar fold appeared posteriorly, helping to close in medullary groove behind, called the tail fold. The mesoblastic cells that lie under the floor of medullary groove separate from other mesoblastic cells, and become elongated to form a rod-like structure—the *notocord.* The hypoblast takes no part whatever in these changes, but lies as a level layer underneath mesoblast.

It (*i.e.*, hypoblast), coincident with the appearance of head and tail folds, &c., becomes invaginated, and thus forms the primative alimentary canal, closed in front and behind. Meanwhile, that portion of the mesoblast lying on each side of notochord, beneath medullary folds, split into two layers—one attaches itself to the epiblast, forming with it the body-walls; the other attaches itself to the hypoblast, and assists it in forming the walls of alimentary

canal. By separation of these two layers of mesoblast from one another, a cavity is found, which afterwards becomes the general body-cavity or pleuro-peritoneal cavity. This splitting of mesoblast does not extend quite up to the walls of the medullary canal, hence there is left along either side of the canal, between it and the line along which the splitting begins, a tract or plate of uncleft mesoblat, which receives the name of vertebral plate. The more external mesoblast, viz. that which splits is called lateral plate. In this vertebral tract the protovertebræ appear. These are merely the mesoblast cells of the vertebral plates cut up into square masses. They do not correspond to the true vertebræ, for not only are the true vertebræ produced by them, but also some of the *muscles and spinal nerves.* It must be carefully noted, that in that part of the embryo which forms the head, the mesoblast is never cut up into protovertebræ, and never undergoes cleavage. The mouth first appears as a pit in the skin, which deepens until it abuts against anterior end of alimentary canal. Communication is made between the two by a solution of the intervening walls. The cloaca is similarly formed. Meanwhile, other parts of embryo are being developed, which may be described systematically.

I.—DEVELOPMENT OF HEART AND BLOOD-VESSELS.

Heart is formed as an elongated tube (contractile) out of a mass of mesoblast lying underneath the anterior part of the alimentary canal. To provide channels for the fluid thus pressed by the contraction of the heart, a system of tubes makes its appearance in the mesoblast throughout the embryo.

II.—DEVELOPMENT OF SPINAL CORD AND BRAIN.

We have seen how primitive cord was formed. It is at first a canal, the cavity of which is of considerable width. By a multiplication of epiblastic cells which line it, the cavity is much narrowed. Thus the anterior and posterior columns and roots of the spinal nerves are formed, as well as the commissures. The cavity of the canal is now a mere slit, which is soon divided by a

transverse partition into two—an anterior and posterior (lower and upper respectively, if cord be supposed to be horizontal.) By the absorption of the roof of the posterior slit, the posterior fissure is formed. The anterior slit remains as permanent central canal of spinal cord. The anterior fissure, which appears before posterior, is formed by growing downwards of the parts of the cord on each side of the middle line, so as to enclose a somewhat linear space.

Brain—Spinal canal dilates anteriorly into these vesicles—anterior, posterior, and middle cerebral vesicles.

From the anterior are produced—

(1) Cerebral hemispheres.
(2) Corpora striati.
(3) Olfactory bulbs.
(4) Optic thalami.
(5) Pineal gland.
(6) Pituitary body or gland (in part).
(7) Third ventricle.
(8) Optic nerve (primary).

From middle cerebral vesicle—

(1) Optic lobes.
(2) Aqueduct of Sylvius.
(3) Optic nerve (secondarily).

From posterior—

(1) Cerebellum.
(2) Medulla oblongata.
(3) Fourth ventricle.

DEVELOPMENT OF ENDOSKELETON.

(a) Vertebral Column—Protovertebræ form true vertebræ, by providing the notochord with a cartilaginous sheath, which becomes constricted to form bodies of the vertebræ, and sends prolongations around spinal cord to form the neural canal.

(b) Skull—Two bars of cartilage appear at anterior part of notochord—the parachordal cartilages. In front of these other two—the trabeculæ cranii. These latter are at first separated from one another and from the former, thus allowing a space to intervene. Through this space the upper and back part of the

mouth communicates with the brain. The trabeculæ then fuse with one another and with the parachordals, and thus cut off the upper part of the mouth, which is transformed into part of the pituitary body. A cartilaginous floor is thus formed beneath brain floor, grows outwards and upwards, fusing with the nasal and ear capsules but not with eye capsules, and tries to roof in head, and so form a complete cartilaginous box. It never, however, completely roofs it in, one or two spaces being covered by the skin.

VISCERAL ARCHES AND CLEFTS.

Below and on the sides of cranial parts of head, a series of processes or bars of cartilage are developed in pairs. The tissue between these bars become absorbed, forming clefts, which remain open for a longer or shorter period. The first cleft lies between the first and second arch, so that there is one more arch than cleft.

There are seven branchial arches and six clefts. Cartilage developed in first arch is called Meckel's cartilage. From near its proximal end another bar of cartilage is given off, which is called the pterygo palatine. This forms the upper jaw, while Meckel's itself forms the lower jaw. Between the two the mouth is formed. From proximal end of Meckel's cartilage another small cartilage is formed—the spiracular or meta-pterygoid—which ossifies as the malleus in man. The second arch is called hyoid, and has three pieces—(1) Hyomandibular, which connects jaws with ear capsule (connected to hyoid by a ligament). (2) Basihyal, which goes to support tongue. (3) Hyoid piece itself.

Other five simply form branchial or gill arches.

The limbs are believed to be formed from arches called extra branchial arches. There are in addition five pairs of labial cartilages:—First pair extending over nasal capsules; second and third pairs above nasal aperture; fourth pair in connection with upper jaw; fifth pair with lower jaw.

OLFACTORY ORGANS.

Two pits, one at each side, appear in primitive head. These deepen, and their lining cells become modified to receive sense

impressions, and have branches of the olfactory nerve going to them. A capsule is formed round each for protection, which fuses with the brain-box.

AUDITORY ORGANS.

On each side of posterior part of head a dimple appears, which deepens into a sac, whose external opening becomes constricted. The sac then gives off three projections in different directions; these become compressed, and central portion absorbed, leaving three canals, the semicircular canals, each of which of course communicates with the primary sac, which becomes the vestibule. A cartilaginous capsule is formed around it for protection, which fuses with the brain-box.

EYE.

Commences as a lateral outgrouth of anterior cerebral vesicle, in form of a stalked vesicle. The stalk becomes narrower and subsequently *solid*, and converted into *optic nerve*. This optic nerve gets pushed backwards, so as to be connected with middle cerebral vesicle, and some of the fibres get pushed over to opposite side, forming the optic commissure.

The optic vesicle is pushed outwards until it comes in contact with the skin (skin—superficial epiblast). The part of skin with which it comes in contact *thickens;* the thickened portion is then pushed inwards in form of a shallow pit with thick walls, carrying before it the front wall of the optic vesicle. To such an extent does the involution of the skin take place, that the front wall of the optic vesicle is pushed close up to the hind wall, and the cavity of the vesicles becomes almost obliterated. The bulb of the optic vesicle is thus converted into a cup with double walls, containing in its cavity a portion of the involuted skin. We may call this cup the optic cup of its double walls—inner or anterior is formed from the front portion, the outer or posterior form the hind portion of wall of the primary optic vesicle. The inner or anterior, which very speedily becomes thicker than the other, is converted into the retina; in the outer, or posterior, which remains, thin pigment is eventually deposited, and it

ultimately becomes the pigment layer of the choroid. By closure of its mouth, the pit of involuted skin becomes a completely closed sac. At the same time it becomes detached from the external skin, which forms a continuous layer in front of it—all traces of original opening being lost. There is thus left lying in the optic cup an isolated mass of skin: this is *rudiment of the lens.* The small cavity within it speedily becomes still smaller by the thickening of its walls, until it disappears altogether. At its first appearance, the lens is in immediate contact with anterior wall of optic cup. In a short time, however, the lens is seen to lie in the mouth of the cup, a space making its appearance between the lens and anterior wall of optic cup. Walls on under surface of optic cup are at first imperfect, as a gap here exists. Through this gap mesoblast, in which eye is embedded, passes out and forms vitreous humour, the gap subsequently closing. The mesoblast immediately surrounding the eye forms the choroid itself (pigmented layer of which we have seen to be already formed), and also the sclerotic. The front portion of walls of optic cup, along with the choroid, bend in front of the lens, and forms the iris. The original wide opening of optic cups is then narrowed to a smaller orifice—the pupil—and lens which lay before in the open mouth is now closed in the cavity of the cup. Superficial skin becomes transparent cornea.

REPRODUCTION AND URINARY ORGANS.

In embryo there are many coiled tubes lying on each side in abdominal cavity, and opening into it by both ends. These being somewhat similar to the segmental organs of lumbricus may be called *segmental tubes.* A common segmental duct is then formed on each side, which opens by one end into the abdominal cavity, and by the other into the cloaca. Into this common segmental duct each segmental tube comes to open by one end. The common segmental duct splits into two—the *wolffian* and *mullerian* ducts. If embryo is to become a male, the former remains and the latter atrophies; and conversely, if embryo is to become a female, the mullerian duct persists and the wolffian duct atrophies. The segmental tubes may be divided into an *anterior, middle,* and *posterior set.* In female, cells

lining abdominal wall on each side multiply and form the ovary. Anterior set of segmental tubes disappear. Middle forms wolffian body, or parovarium, of unknown function. Posterior forms the kidneys with their duct (ureter). Müllerian duct forms oviduct. Kidney is thus formed of a number of tubes collected in groups, forming the glomeruli of kidney. By blood-vessels being much broken up in these glomeruli, the flow of blood is slow, and thus watery contents are extracted. In male, anterior segmental tubes form vasa efferentia and epididymis; middle set form wolffian body. Posterior—the kidney. The lower portion of wolffian duct remains as the vas deferens.